KNOWLEDGE

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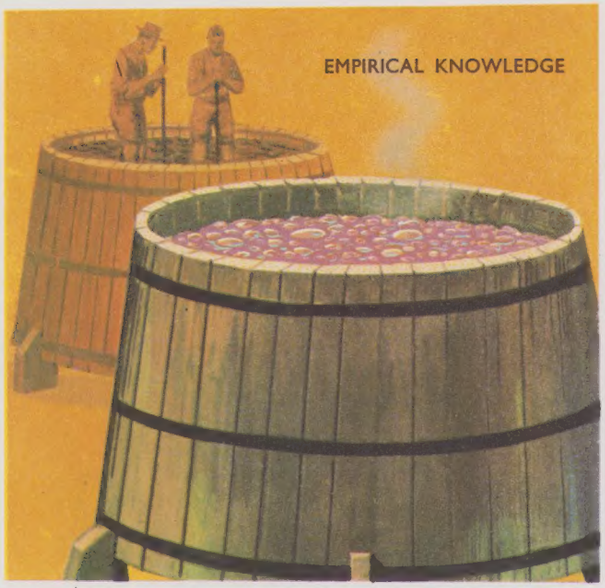
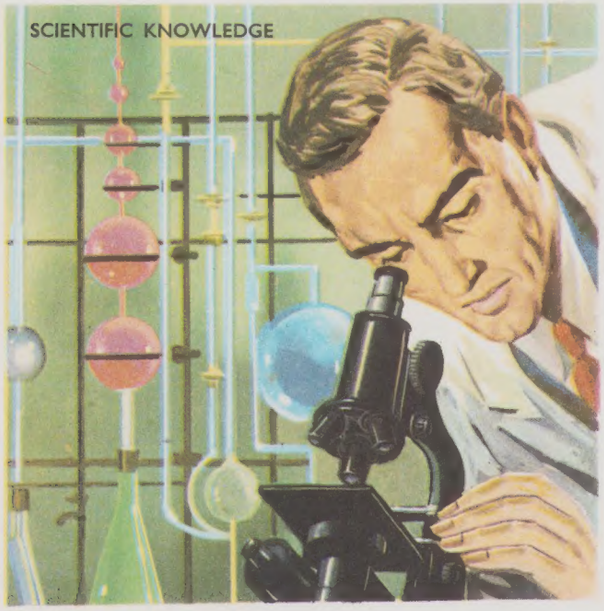
SCIENCE (part two)



The peasant knows from long experience ('empirically') that grapes crushed in a vat turn into must which 'boils up' after some days and becomes wine



The scientist tries to explain why must turns into wine. To explain something is to show that it happens because of something else. Thus, the scientist tries to show that crushed grapes turn into wine because of some change in the plant substance

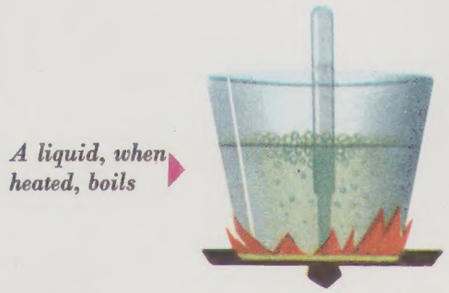
THE word 'science' comes from the Latin verb *scire*, to know. Science simply means knowledge, therefore. But it is knowledge of a special kind; that is, organised and systematic knowledge. The scientist is not content merely to record what happens; he also tries to find out why things happen.

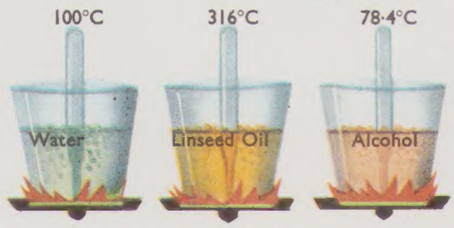
He may start with a piece of 'empirical' knowledge, which means that it is gained from practical experience; for instance, that water boils when heated to a certain temperature. But he will not rest there: he will go on to enquire into the exact conditions under which water boils. Going further still, he will try to explain why liquids in general boil: why every liquid boils at a certain temperature; why, when other substances are dissolved in a liquid, its boiling point changes; how the boiling point of a liquid changes when the pressure of the surrounding atmosphere changes; and many other such facts.

With the help of all these findings the scientist sets up a general hypothesis (supposition made as starting-point for investigation) about the boiling of liquids, which fits in with all these facts, and from which others, so far unknown, can be worked out. He then makes experiments to see whether the hypothesis correctly forecasts what will happen.

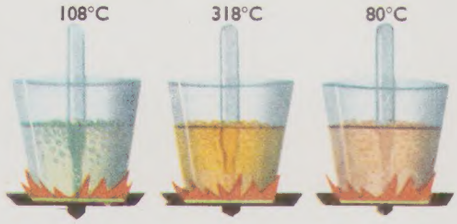
The scientific attitude towards the world was first developed by the scientist philosophers of Ancient Greece. During the Dark Ages it suffered a setback, but was revived by the great scientists of the 16th and 17th centuries and has come more and more to govern modern life.

One of the main characteristics of scientific work is that every minute fact has to be observed and analysed detail by detail. It is on the basis of such work that the scientist draws his conclusions with great care and precision. Sometimes, like the artist, he makes a discovery through inspiration, but principally he gathers evidence in a practical way.

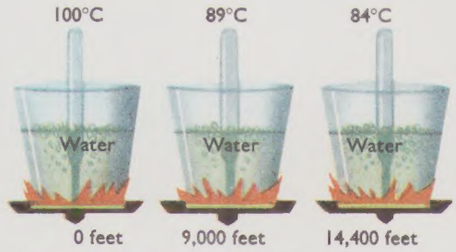




The boiling point of every liquid is at a different temperature



A liquid's boiling point changes if another substance is dissolved in it



A liquid's boiling point falls the greater the altitude

Some simple experiments carried out by scientists on the phenomenon of boiling. Through these, and through other more complicated experiments, they have discovered the true nature of this very well-known phenomenon

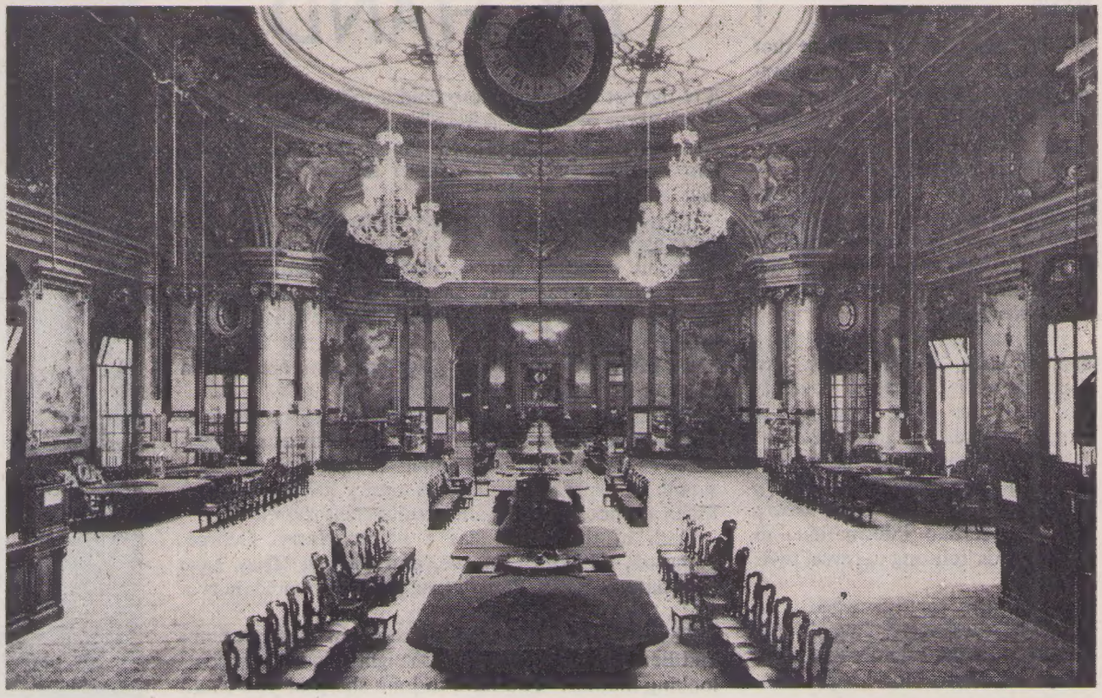
Previous page: The enormous development of science in the last few decades has increased the specialisation of scientific studies. The illustration shows: for chemistry, apparatus in common use; for physics, the disposition of the atoms in a molecule of methyl alcohol; for biology, a drawing of a plant cell; for palaeontology, a reconstruction of the *Ceratosaurus nasicornis*

KNOWLEDGE NEWS

Week beginning 26th May 1963

MEN WITH MILLIONS TO PLAY WITH

(continued on page 2)



Inside the Casino of Monte Carlo – here enormous fortunes have been won and lost. Overnight rich men have become paupers, and vice versa.

A summer playground of the rich – the beach at Cannes (above). The French Riviera has for a long time been the focal point of the international set, although some of its exclusiveness has vanished. The Bahamas and Bermuda are today providing strong counter-attractions for the rich.

£ £ £ £ £ £ £ £

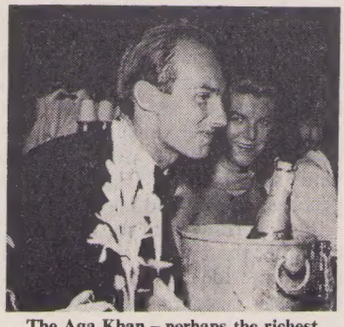
A winter playground of the rich – St Moritz (above right), the world-famous ski-resort.

$ $ $ $ $ $ $ $

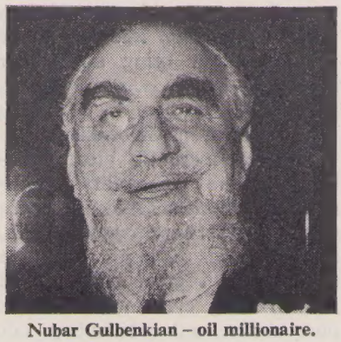
Lying in Monte Carlo harbour, 'Christina', the luxury yacht belonging to Greek shipping owner Aristotle Onassis. A yacht is an essential part of the equipment of the really rich man: a means of escape from the gaze of lesser mortals.

FOUR OF THE RICHEST MEN IN THE WORLD

Paul Getty – the richest man in the world.



The Aga Khan – perhaps the richest young man in the world.



Nubar Gulbenkian – oil millionaire.

Aristotle Onassis – shipping millionaire.

Letter from the Editor

37 HERTFORD ST.
LONDON W.1

IT has been pointed out to me that the editor of our historical newspaper on 'Peterloo' could, if he were actually living in 1819, have faced some serious charges for revealing government secrets.

Moreover, he would have certainly been ostracised from 'Society', as it was then considered very 'bad form' for editors to criticise the Government, and take the side of the 'lower classes'.

Fortunately, our editor was spared both imprisonment and social ignominy. However journalists today are by no means free from the threat of imprisonment. Recently they have been imprisoned for refusing to tell a government tribunal from where they got certain information – in other words 'refusing to reveal their sources'.

To return to the subject of *historical* newspapers: I would like to thank all the schools who submitted entries for our competition. So far we have received over a thousand entries from British and Irish schools, and we expect many more from overseas.

John Chancellor

HE FEEDS A THOUSAND FISH BY HAND

IN the last two years more than a million people from all parts of South Africa have visited the Durban Centenary Aquarium to see one of the most unusual shows in the world: a skin diver feeding hundreds of fish by hand.

Twice a day 28-year-old Bert Roets puts on an aqualung and takes 50 pounds of food (sardine, crayfish, hake and stockfish) into the 45-foot-wide tank.

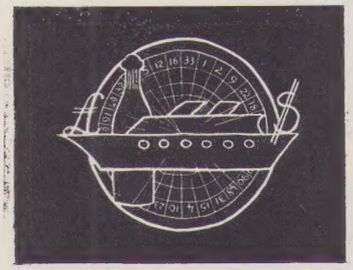
When he appears the fish mill round him eagerly, anxious for their food. Indeed sometimes they cannot wait for him to open the food container, for they take small bites from their provider – Bert's arms are covered in scars from these nibbles.

There are more than a thousand fish in the 186,000-gallon-tank, and Bert knows them all. Visitors are fascinated as they watch him popping sardines into a shark's mouth or tempting turtles with a juicy hake – even tiny fishes are not forgotten and receive their share.

Each of the turtles has a name: Harry, George, Sampson, Claridges, Myrtle, and Shirley. 'They have nice natures,' says Bert. 'None of them would hurt a fly.'

There are three varieties of shark in the aquarium, and Bert will pop a piece of fish right into their wicked-looking mouths. 'You have to look sharp or you could lose a finger,' he says.

What Bert likes best is to see the visitors as they peer through the sides of the aquarium. 'I've got used to seeing all the fish around me,' he says, 'but what amuses me most is watching all the faces behind the glass windows. I can never hear what they're saying, but their expressions are priceless.'



MEN WITH MILLIONS TO PLAY WITH (continued from page 1)

THERE are a number of people whose names regularly appear in the gossip columns of the newspapers. They may not have done anything out of the ordinary – but simply because *they* have done it, it is considered to be news.

What they do and the way they do it seem eternally to fascinate lesser mortals who have to be content with ordinary lives.

International set

These much-publicised people are the so-called 'international set', and what they have in common is vast wealth. Their journeyings and seemingly endless holidays on luxury yachts or at famous resorts never fail to be noticed.

They think nothing of having lunch in London, and hopping over to Cannes – in a private plane, of course – for dinner, and then spending a few hours at a casino. The international set nearly always seem to have sun-tans, elegant clothes, and a great liking for dark glasses, even when it is raining.

Take Mr Aristotle Onassis. He is a Greek shipping millionaire. He has luxurious homes in different parts of the world, the almost inevitable yacht, and is a patron of the arts. He is fond of the Bahamas and Monte Carlo, where he recently opened an American-style drug-store opposite the Casino. But it is a drug-store with a difference. It has rows of 'one-armed bandits' or fruit machines. Presumably if one fares badly in the Casino it is possible to walk over to this store, buy a packet of aspirin, and see if the fruit machines bring any better luck.

Flamboyant Gulbenkian

Another man of great flamboyance and personality is oil-millionaire Nubar Gulbenkian. He was, of course, born to great wealth, and he seems to enjoy it to the full. With his great bushy beard and bristling eyebrows, he is at once bizarre and outstanding; not the sort of man to go unnoticed in a crowd.

He is a lover of good food, cigars, and is something of a humorist. The story is told of a journalist who went to interview him at his London home. He and the journalist had just settled down to talk when Mr Gulbenkian reached into the pocket of his red waistcoat and produced a whistle. He gave one shrill blast and a valet entered the room.

'Bring us two brandies,' said Mr Gulbenkian. The valet did not even look surprised – but the journalist did.

Last year, when he was involved in a legal action with the B B C, Mr Gulbenkian hired a private room at the court, and had his lunches brought in by a string of waiters. Sample menu: melon laced with wine, cold salmon with green mayonnaise sauce, duck with cherries, wild strawberries, English white peaches, whisky and lager.

The hearing lasted for four days, and after the first day people would gather outside the court at lunch-time just to see the trays of magnificent food being taken in.

At the other end of the age scale is the young and athletic Aga Khan. He also has unlimited wealth, but he works hard at being good at things he can enjoy in the company of his young and not so wealthy friends. He is an expert skier, and earlier this year won a competition in which he beat the Dutch, Belgian and Danish champions. But his extraordinary position in life means that he can, for instance, order a new harbour to be built on the shores of the Mediterranean beneath his home on the French Riviera; estimated cost, £80,000.

The richest of all

One millionaire who tends to keep to himself is Paul Getty. However, not long ago he gave a party at his home in Sutton Place, Guildford, which cost over £10,000. There were 1,200 guests; 10,000 flowers arranged in patterns of white and gold; two dance floors, one by the swimming pool; and three bands, one flown specially from Paris. But on the whole Getty seems to prefer the quiet life rather than the traditional rich men's playgrounds – and he is richer than any of them!

VEGETATION OF THE SAVANNAH AND STEPPE

IN order to understand what savannah and steppe really are, we must try to imagine the Earth before man came on the scene with his axe and saw. Fertile regions, with moderate to high rainfall, were covered with forest. This was true of Britain and most of Europe. Very dry regions were desert then as they are now. Between desert and forest there were vast areas of country with enough rain (usually in one short season of the year) to support a considerable amount of vegetation, but few trees.

These areas form steppe in the cold and temperate regions and savannah in the tropics. They can be defined as the temperate and tropical grasslands, because grass is the most characteristic feature of their vegetation. In general the plants are *xerophytic* (adapted to withstand drought), because there is a very long dry season, hot on the savannah, cold on the steppe. Many of the savannah trees shed their leaves in the dry season, while others are adapted to store water in their tissues. Some of the herbaceous plants are resistant to drought, like the grasses; others store food underground in bulbs or rhizomes and remain inactive in the dry season; others again are short-lived, but their seeds live through the drought.

The savannah

The word *savannah* comes to us, through Spanish, from Carib, a native language of the West Indies, and means 'plain'. It is now applied to the country which borders the equatorial forests, lying between them and the hot deserts. The most extensive savannah lands are in Africa, but the *Llanos* of South America and areas in northern Australia are also of this type.

The African savannah is covered with very tall grass called elephant grass, which grows as much as 15 feet high in the wet summer season, and grass is everywhere characteristic of savannah country. For this reason enormous herds of cattle are grazed on it.

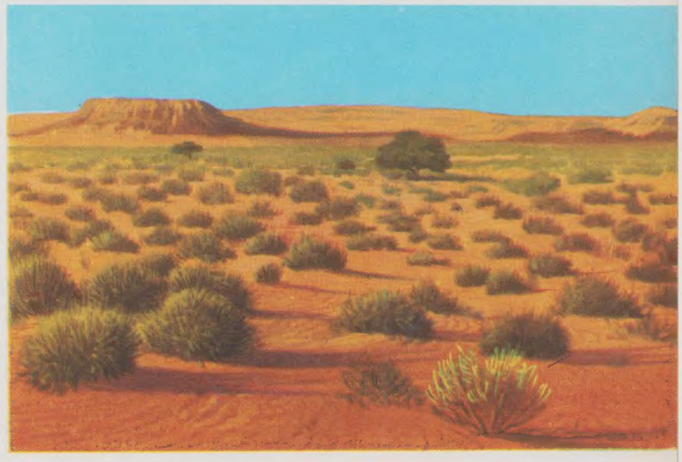
Landscape of the African savannah

Scattered trees grow on the savannah, and are adapted to take advantage of the wet season and survive the dry one. Many of them lose their leaves in the dry season. The few evergreens have leathery leaves and thick, corky bark. Some are able to store water in their tissues; these include the Euphorbias (which look rather like cactuses), and trees which store water in greatly thickened trunks, such as the giant baobab tree of Africa and the curious bottle trees of the Australian savannah.

The steppe

The word *steppe* (see page 524) was originally applied to the grassy, treeless plains of Russia, lying north of the deserts and south of the great northern forest or *taiga*.

Steppe differs from the savannah mainly in that its dry winter season is cold. The combination of drought and cold harms the vegetation more than the hot season of the savannah, and the intensely dry, cold wind of winter prevents the growth of trees almost entirely. The grass of the steppe is short and withers brown in the winter, when it is often covered with snow. The spring and early summer is warm and wet; the grass then grows rapidly, and a great variety of flowers springs up. Many of them have lived since the previous season in the form of bulbs or rhizomes underground; some of our favourite garden plants, like the tulip, were originally natives of the steppe. Equivalents of the steppe elsewhere are the North American prairie and the pampas of South America. The steppe and prairie now contain the richest wheat-growing lands of the world.



Area of transition between steppe and desert

RAIN AND DROUGHT ON THE SAVANNAH AND STEPPE

During the dry season (late summer and winter on the steppe, 'winter' on the savannah) all the vegetation withers away or remains in an inactive condition, either in the form of seeds or of underground storage organs. The drought affects not only the life of the plants; the animals, too, are terribly short of water, and in unusually dry years many of them die of thirst.

When the rain falls everything comes quite suddenly to life. The dry, brown grass is quickly covered by a new green growth, the savannah trees soak up the plentiful water and come into leaf, and the steppe and prairie are gay with flowers. All the plants must do their growing, flowering, and setting of seed in a hurry to take full advantage of the short rainy season.

THE PLANTS

GRASSES. These are the plants that really give their character to the savannah and steppe. The very tall elephant grass covers great areas of savannah in Africa, and feather grass (*Stipa pennata*) is characteristic of the steppe. The well-known Spanish esparto grass (*Stipa tenacissima*) is an allied species; ropes, baskets, and paper are made from it. *Lygeum spartum* is a similar tough, fibrous grass used for the same purposes.

Since the steppe and prairie are the home of so many wild grasses, it is not surprising that cereals such as wheat (which are really cultivated grasses) grow well on them in the areas where the rainfall is not too low. For centuries the grass has been used as grazing for sheep and horses.

TREES AND BUSHES. The trees that we show are savannah plants – the steppe is practically treeless. All of them are adapted to survive a long season of drought. The normal-looking trees and bushes either lose their leaves during the dry season or, if they are evergreen, have very tough and leathery leaves. Typical savannah trees are the lotus tree (*Zizyphus lotus*), whose fruit is supposed to be the lotus of antiquity, acacia (one species, *Acacia senegal*, yields gum arabic), and tamarisk (*Tamarix articulata*), which is a low bush.

Other trees and bushes cut down the rate of water loss or *transpiration* (see page 1505) by having no leaves at all; the vital processes normally performed by the leaves are carried out by their stems. Examples of these are the joint-firs (*Ephedra*), in which the leaves are reduced to tiny scales, and some species of Euphorbia, like the

candelabra euphorbia (*Euphorbia abyssinica*). This plant has very thick green stems and it stores water in its inner tissues. Euphorbias of this kind are very like cactuses in appearance, though the two groups of plants are not related to each other.

Among the strangest savannah trees are those which store water in the trunk. One of the best known is the African baobab (*Adansonia digitata*), one of the most massive trees in the world. It is not very tall, but the trunk may be 30 feet in diameter, with a circumference of 100 feet. The enormous trunk and lower branches act as a reservoir of water; the wood is rather soft and pulpy. Other trees which store water in this way are the Arabian species *Adenium socotranum*, and the remarkable bottle tree of northern Australia, *Brachychiton rupestris*. This tree gets its name from the shape of its trunk, which is moderately wide at the base, becomes wider higher up, and then narrows; it is in fact shaped like a bottle, and it serves the same purpose, to store liquid. The inside of the trunk, like that of the baobab, consists of rather soft, spongy wood.

OTHER PLANTS. Many kinds of herbaceous plants grow on the steppe and savannah, most of which lie dormant during the dry season. The agaves of the American savannah and semi-desert, however, remain permanently above ground and have very thick, hard leaves. The century plant (*Agave americana*) sends up a very tall flowering shoot at intervals of many years; sometimes over 50 years elapse between one flower and the next, but it is an exaggeration to call it the 'century plant'. From *Agave sisalana* is obtained the very valuable sisal fibre.

ELIZABETH AND HER SEA-CAPTAINS

Francis Drake being knighted by Queen Elizabeth I aboard the Golden Hind *at Deptford in* 1581

DURING the reign of Queen Elizabeth I many men achieved fame, and particularly outstanding were the sea-captains Drake, Hawkins, Frobisher, Gilbert, Grenville, and Raleigh. Elizabeth had a genius for choosing able servants, and for binding them to her by ties of deep loyalty and personal affection. Although her sailors were often angered by her unwillingness to make up her mind, they were, nevertheless, devoted to her. They gave their lives in her service, to destroy the power of Spain, to discover new sea-routes for trade, and to found English colonies in America. Elizabeth kept an uneasy peace with Spain for years, and turned a blind eye upon the activities of her 'sea-dogs', who preyed upon the Spanish merchant fleet in the Atlantic, and raided Spanish ports, bringing home rich prizes for their Queen.

Sir Humphrey Gilbert colonised Newfoundland; Sir Martin Frobisher sought the 'North-west Passage', and was one of Elizabeth's bravest captains in the long struggle against Spain; Sir John Hawkins was her Comptroller of the Navy, and his far-sighted seamanship was responsible for the building of the fast, agile ships which defeated the Spanish Armada. Many died in the Queen's service. Undoubtedly the most famous of Elizabeth's sea-captains was Sir Francis Drake, whose very name was dreaded by his Spanish enemies.

Drake's voyage round the world

In 1577 the Queen sent for Drake, and said: 'Drake, I would gladly be revenged on the King of Spain for the injuries I have received.' With the Queen's support, an expedition was fitted out, and in December of that year Drake set sail in his flagship, the *Pelican*, with the *Elizabeth*, the *Marigold*, the *Swan*, and four smaller ships. We do not know exactly what his secret orders were. It was believed that he was sailing to discover *Terra Australis Incognita*, the great continent which geographers believed to lie across the southern expanse of the Pacific Ocean, but perhaps he also had the Queen's orders to attack the rich Spanish colonies in South America.

At sea, he changed the name of the *Pelican* to the *Golden Hind*. She carried 18 guns, and was, by 16th-century standards, a very well-equipped ship, with a crew of 80 men. Seven months later, in June 1578, he sailed through the Magellan Straits at the southern tip of South America. Here, Drake executed Thomas Doughty, one of his gentlemen sailors, whom he suspected of treachery. 'Let us show ourselves to be all of a company,' he said in a speech to his officers and men, and he offered to send the *Marigold* home with any who did not wish to go farther. But no one volunteered to go. Soon after this, the *Swan* was abandoned as unseaworthy, and a little later the *Marigold* sank with all hands, and the *Elizabeth* was lost sight of; in fact she had turned for home and reached Devon 12 months later. Drake pressed on up the coast of Peru, raiding Spanish ships and ports, and taking enormous booty in silver, gold, and jewels, including emeralds which he later presented to the Queen as a personal gift. Finally, the Spaniards set out to destroy him, and he left South America, crossed the Pacific to the Spice Islands, and after a hazardous voyage across the Indian Ocean, rounded the Cape of Good Hope, and sailed for home. On 26th September 1580, after a voyage lasting nearly three years, he anchored in Plymouth.

His treasure was worth about a million and a half pounds, half the yearly produce of King Philip of Spain's South American mines. On New Year's Day, 1581, the Queen wore a crown given her by Drake, set with five splendid emeralds, and later that year she knighted him aboard the *Golden Hind*.

The invincible Armada

England was moving nearer to war with Spain, and King Philip was equipping a fleet for 'The Enterprise of England', the great naval attack which was intended to cripple England's power for ever. Drake made numerous raids against Spanish ports and ships, and in 1587 attacked Cadiz, where he destroyed the Spanish fleet, and returned home triumphantly, having, as he said, 'singed the King of Spain's beard'.

In May 1588 the Spanish Armada left Spain to sail up the Channel, unite with the Spanish forces under Parma in the Netherlands, and invade England. Drake sailed from Plymouth with his commander-in-chief, Lord Howard of Effingham,

manœuvred the English fleet to windward of the Spanish, and engaged them in a running fight up the Channel. Harried by the English, disordered by attacks from fireships, and driven by strong winds, the remains of Philip's proud Armada fled through the North Sea, and tried to make their way round the north of Scotland towards home. Only about half reached Spain; 64 ships and 10,000 men were lost.

Drake was now nearly 50. Though he made several more raids on the Spaniards,

Sir Francis Drake (*about* 1540–1596)

the highest peak of his career was passed. In 1595 he set sail once more for the Spanish Main together with his cousin and old friend, Sir John Hawkins. Both admirals died on this expedition. Drake died on 27th January 1596, and was buried at sea, in the Spanish Main. To his enemies he had been known as 'the Dragon', the scourge of every Spaniard.

Raleigh and the new world

Raleigh, like Drake, came from Devon, a part of England which has bred many of her finest sailors. When he first came to the Court, in 1582, Walter Raleigh was already an experienced sailor and soldier. Now he showed himself an accomplished courtier. A man of striking appearance, he at once attracted Elizabeth's attention, and soon became one of her favourites. She knighted him and later made him Captain of the Guard.

Raleigh long dreamed of founding an empire in America, and used much wealth and energy in endeavours to make the dream come true. He built the splendid four-masted ship the *Ark Raleigh*, in which he intended to sail the Atlantic, but it sailed to America without him, for the Queen would not let her favourite leave Court. The colony was founded by two of Raleigh's captains, and named Virginia, but years were to pass before he himself was to see the New World of which he dreamed.

As the storm clouds of war gathered in 1588, Raleigh was sent to the West of England to organise the defences. No sooner was the Armada defeated than he was planning to lead an expedition to South America. At last, in 1595, Raleigh sailed for Guiana, stopping first at Trinidad. He explored the Orinoco River for 400 miles, trying to find the legendary *El Dorado*, the Land of Gold. The river rose in flood, and he and his men were forced to return. 'Our hearts were cold,' wrote Raleigh, 'to behold the great rage and increase of Orinoco.'

Spain had now recovered much of her power. Drake and Hawkins were dead. It seemed that England was again threatened. Raleigh, Essex, and Howard led an expedition against Spain, and after severe fighting the Spanish fleet was destroyed and Cadiz left in flames. Raleigh himself received a leg wound and limped for the rest of his life. The death of Elizabeth in 1603 left him defenceless against jealous enemies, and the new king, James I, distrusted him. James imprisoned Raleigh in the Tower for nearly 13 years, and he was only released when James, desperate for money, sent him across the Atlantic again to find the wealth which he had tried to discover before. Had he found it, King James might have spared his life, but the expedition was a failure. One of Raleigh's

Sir Walter Raleigh (*about* 1552–1618)

Sir Richard Grenville (*about* 1541–1591)

sons was killed, and Raleigh returned home in 1618, old and grief-stricken, to be beheaded in Westminster Palace Yard.

The last fight of the *Revenge*

Sir Richard Grenville spent much of his life in the West Country, where he was Sheriff of Cornwall. Like Raleigh, he was involved in schemes to colonise America, and made several voyages to Virginia. His daring exploits against Spanish ships made him one of the most feared of English sailors. When the Armada sailed in 1588, Grenville provided several ships for the Queen's fleet, though he himself, with Raleigh, organised the land defences.

In 1591, as Vice-Admiral to Lord Howard, Grenville sailed in the *Revenge* to the Azores, to lie in wait for the Spanish treasure-ships from the Indies. But a fleet of warships sped out from Spain, and the English ships were taken by surprise, many with their sails furled, and their men ashore, getting supplies. The *Revenge* was separated from the rest of the fleet and left to fight alone. She was boarded, and a desperate hand-to-hand fight went on till the ship was like a slaughterhouse. Mastless and broken, the *Revenge* fought on till nearly midnight, when Grenville was seriously wounded. He commanded the master gunner to split and sink the ship, but his captain, to spare the crew, surrendered to the Spanish admiral, and Grenville was carried aboard the *San Pablo*. He was honourably treated and his wound was tended, but he died within two days. The last words of one of Elizabeth's bravest sea-captains were reported to be: 'Here die I, Richard Grenville, with a joyful and quiet mind, for that I have ended my life as a true soldier ought to do, that hath fought for his country, Queen, religion, and honour.'

THE LESSER ANTILLES AND THE BAHAMAS

THE islands known as the Lesser Antilles are situated in the Caribbean Sea to the north of South America and are part of the group of islands called the West Indies. The Greater Antilles islands are also in the West Indies, and include such large islands as Cuba, Hispaniola, Jamaica, and Puerto Rico. The Bahama Islands, which are another group in the West Indies, lie in the Atlantic Ocean to the east of the mainland of North America.

The Lesser Antilles consist of the Virgin Islands and the Leeward Islands in the north and the Windward Islands in the south, and another archipelago lying off the north coast of Venezuela.

The geographical position of the Lesser Antilles

SOME GENERAL CHARACTERISTICS

The islands are of two main types: some of them are generally flat and receive little rainfall, while others are very rugged and mountainous, and have far more rain. The former, often long and narrow, are of coral formation and encircled with reefs, while the latter are volcanic cones, some of which have recently been active.

Few of the original inhabitants of the islands now remain, although there are some Caribs to be found – in Dominica, for example. Most were killed or died from European diseases soon after the Spanish conquest. In order to provide themselves with a reliable labour force, the white settlers imported negro slaves from Africa. The descendants of these negroes now form the greater part of the population of the islands.

THE BAHAMAS

The Bahamas lie to the north of Cuba and the east of Florida, and rise from a vast submerged plateau. Because of their lack of relief (the highest point barely exceeds 250 feet), they have a low rainfall, and the natural vegetation is a scrub of palms and pines rather than true forest.

The Bahamas consist of some 2,000 separate pieces of land, most of which are small, uninhabited islands. Only 20 of the islands are inhabited; their present population is 106,677.

At one time the Bahamas had flourishing sponge fisheries, but they now concentrate on the export of vegetables, particularly of tomatoes to the United States. Pineapples, citrus fruits, bananas, and coconuts are also grown. The scrub land supports horses, cattle, and sheep.

The prosperity of the Bahamas depends to a great extent on their success as a winter resort, and on the attraction of their fine bathing beaches to visitors, especially from the United States of America which is within easy travelling distance. For this reason many hotels and villas have been built to provide accommodation. The largest town in the Bahamas is the capital, Nassau, where more than half of the total population lives. There are few industries: some trees are felled for lumber, and charcoal is made. Salt is obtained by the evaporation of sea-water.

A panoramic view of the city and port of Nassau in the Bahamas

THE LESSER ANTILLES

THE VIRGIN ISLANDS. Three of the larger and some of the smaller of the Virgin Islands belong to the United States, and 11 of them, of which the largest is Tortola, belong to Great Britain. The total population of the three large American islands – St Croix, St John, and St Thomas – is 32,099. St John is well known for its production of bay leaves, which are collected from the wild scrub forest, and St Croix for the rum which is made from the sugar cane grown there.

THE LEEWARD ISLANDS. The islands include Antigua, St Kitts, Nevis, Anguilla, Montserrat, and the British Virgin Islands. Antigua, 108 square miles in area, with a population of 55,000, is the most heavily populated. It is fairly flat, and has a rather dry and very sunny climate. The chief crop is sugar, but this can be grown only where the soil retains moisture. St Kitts and Nevis, which together have a population about the same as that of Antigua, produce sugar, and Nevis is also important for its cotton. Montserrat, on which 12,157 people live, specialises in the production of cotton, tomatoes, and limes.

GUADELOUPE. This is a French possession, lying in the centre of the Lesser Antilles. The territory has an area of about 687 square miles, including smaller neighbouring islands, and a population of 274,774. Guadeloupe consists of two main islands, separated from each other by a narrow tidal channel filled with mangrove swamp. Grande Terre, in the east, is low and flat and devoted to sugar production. Basse Terre in the west is mountainous; the volcanic peak of Soufrière, which rises to 4,869 feet, is the highest peak in the Lesser Antilles. In contrast to Grande Terre, Basse Terre grows a variety of crops, including bananas, coffee, cocoa, and vanilla, but agriculture is severely limited by the rugged topography.

DOMINICA. This island lies to the south of Guadeloupe, and was transferred from the Leeward Islands Colony to the Windward Islands in 1940. It has an area of about 304 square miles, and is the largest of the Windward Islands. It has a population of 54,124. Dominica, which is of volcanic origin, is very rugged, and settlement is mainly limited to the coast. Lime juice, lime oil, and fresh fruit are

A modern Caribbean hotel

View of St Pierre (Martinique) at the foot of the famous Mt Pelee

The island of Barbados is geologically part of South America, because it stands on the continental shelf. It is composed of coral limestone overlaid with volcanic ash. The island rises in terraces to a central ridge of 1,100 feet. The moderate rainfall sinks into the limestone, and there is practically no surface drainage; the water which flows through underground passages is pumped to the surface. It has been a British colony since 1625. By 1640 there were 37,000 white people on the island, together with 6,000 negro slaves. By the end of the 18th century there were only 16,000 whites, but more than 60,000 negroes. Only about 5 per cent of the present population of 232,085 is white. This trend has been a common one in the West Indies. Sugar is the chief crop and provides the greater part of the exports. Other crops grown in rotation are maize, yams, cotton, and vegetables. Bananas are also cultivated.

Grenada has a population of 88,677. As in the other islands, agriculture is the chief means of support. The main exports are cocoa, nutmegs, mace, cotton, limes, and bananas.

St Vincent, with a population of 80,042, is the world's chief producer of arrowroot. A wide range of crops is grown, including sugar, from which rum is made, cotton, coconuts, cocoa, and bananas.

Map of the Lesser Antilles

the chief exports. Bananas, coconuts, oranges, cocoa, grapefruit, mangoes, and vanilla are also sent to other parts of the world from Roseau, the main port.

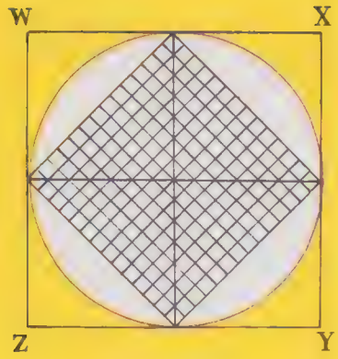
MARTINIQUE. To the south of Dominica is another French possession, the island of Martinique. With an area of 427 square miles it supports a population of 247,000. The island is volcanic and is particularly rugged. Its former capital, St Pierre, was destroyed by the famous eruption of Mount Pelee on 8th May 1902, when almost all the population of about 30,000 people was killed. The present capital is Fort-de-France, which lies among the vast sugar fields of the Lamentin Plain, the only sizeable piece of flat land on the island. The rum produced on Martinique from the sugar grown there is much prized in France. Many other crops are grown, including coffee, cocoa, pineapples, coconuts, bananas, tobacco, cotton, and vanilla.

THE WINDWARD ISLANDS. Except for Dominica, these lie to the south of Martinique. The largest are St Lucia (233 square miles), Barbados (166 square miles), Grenada (133 square miles), and St Vincent (150 square miles).

St Lucia is a rugged, volcanic island with a population of 94,718. Castries is the chief port, and is one of the finest harbours in the West Indies. Sugar is the most important crop, followed by limes, bananas, and coconuts. The island is heavily forested.

There remain the islands in the south lying off the north coast of Venezuela. The three farthest to the west belong to the Netherlands, and are the most important. Curaçao has a population of 123,689, Aruba 53,199, and Bonaire less than 5,592. These islands on the whole receive little rainfall, and are used mainly for pasturing goats, though Curaçao is the home of the famous Liqueur of that name. In strong contrast to the rest of the Lesser Antilles, most of the population of Aruba and Curaçao lives in towns. It is here that much of the oil from Maracaibo in Venezuela is refined. About 30 per cent of those employed in Curaçao and 40 per cent of those in Aruba gain their livelihood either at the refineries or in the shipping establishments concerned with the transport of the finished product.

Pi (part two)



THE area of the circle on the right is less than the area of the large square WXYZ, but this square can be divided up into four smaller squares, whose sides are the same length as the radius of the circle, and each of which has an area of r^2. So we see that the area of the circle is less than the area of these four small squares. We can write this in a short form, using the sign $<$ to mean 'is less than', and A for the area of the circle.

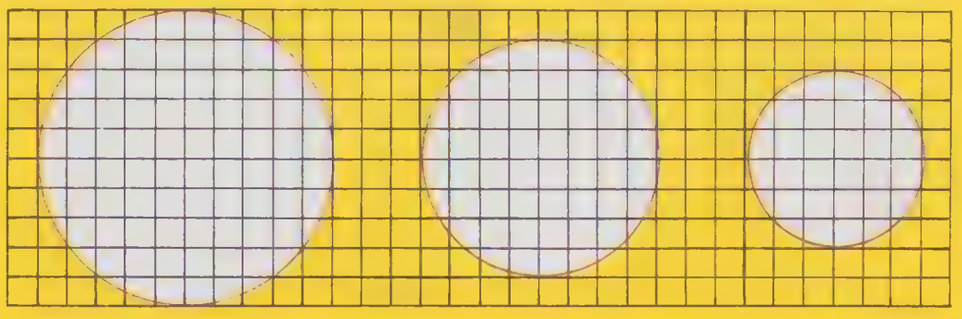
$$A < 4r^2$$

We can see also that the area of the circle is greater than the area of the four shaded triangles, but these four shaded triangles form two of the small squares. Using the sign $>$ to mean 'is greater than', we write this

$$A > 2r^2$$

We see then that A is some fraction of $4r^2$, the fraction being between two and four. Could it possibly be π?

Let us experiment with the previous circles (see page 1946). If we place them on a square grid we can calculate their areas by counting the small squares inside them. Where fractions are involved, our calculations will have to be approximate.

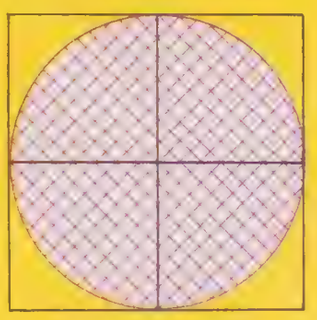


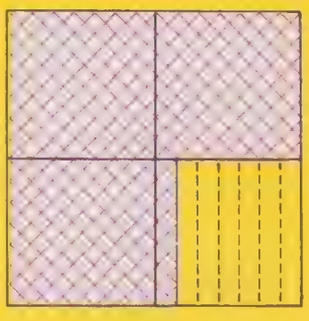
	Circle 1	*Circle* 2	*Circle* 3
Radius (r)	5 units	4 units	3 units
Area (A)	79 sq. units	50 sq. units	28 sq. units
r^2	25	16	9
$\frac{A}{r^2}$	3·16	3·12	3·11

It would appear that the ratio of the area of a circle to the square of its radius is again this number π.

$$\frac{A}{r^2} = \pi \text{ or } A = \pi r^2$$

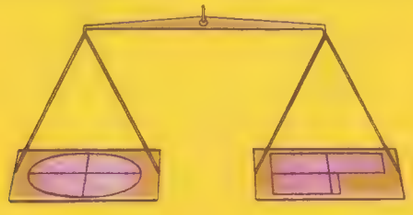
If we use the approximate value of $3\frac{1}{7}$ for π, we can write this as $A = 3\frac{1}{7}r^2$. We can see what this formula implies in the diagrams on the right.





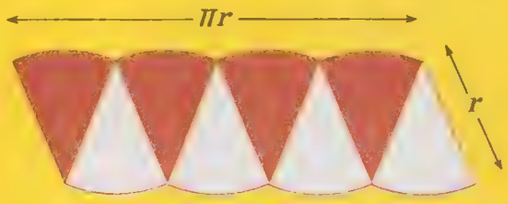
The area of the circle is equal to the shaded area, consisting of three squares whose sides are equal in length to the radius of the circle, plus one-seventh of another square.

If these shapes were made from card of the same thickness, they would balance when placed either side of a scale balance.

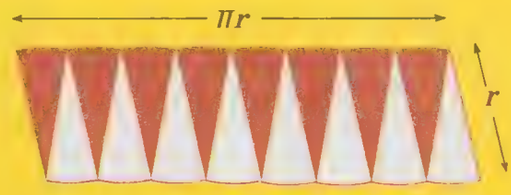


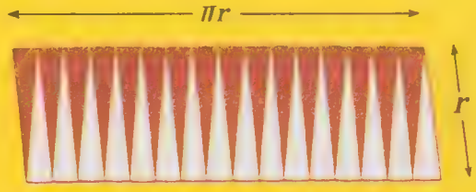
Can we show that the formula $A = \pi r^2$ must be true? After all, our experiment only suggested the result; it was no proof.

We will begin by dividing any circle into sectors and rearranging them as shown.

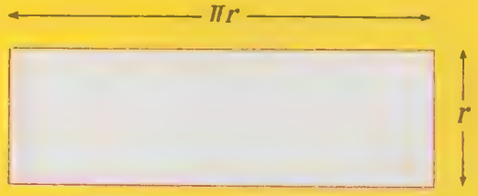


The areas of the two shapes 1 and 2 are equal, and we also note that as the circumference of the circle is $2\pi r$ the lengths of the upper and lower sides of figure 2 are πr units each. However small the sectors are, these results will still be true. Let us see what happens as the sectors get smaller.





We can see that the shape of the rearranged sectors is getting nearer and nearer to a rectangle as the sectors get smaller.



This indicates that as the area of the rectangle is $\pi r \times r$ square units, the area of the circle being equal in size to the rectangle is also given by $A = \pi r^2$ square units.

R A P H A E L

Self portrait of Raphael as a young man
(Ashmolean Museum, Oxford)

WHEN we think of the Italian Renaissance, the names of three great painters immediately come to mind – Michelangelo (see page 929), Leonardo da Vinci (see page 353), and Raphael. They all lived at about the same time. Raphael, the youngest, was born in the village of Urbino in 1483. At this time Michelangelo was 8 years old and Leonardo 31.

As a boy Raphael learned to paint from his father, and by the age of 17 was working and studying under Perugino. This well-known Umbrian painter was famous for his serene and well-balanced compositions with their backgrounds of buildings and landscapes. We can see his influence clearly in Raphael's early works – for example, in *The Marriage of the Virgin*, dated 1504.

The Marriage of the Virgin, *painted in* 1504
(Brera Gallery, Milan)

In this picture you can see how the architectural background is a distinctive feature, kept quite separate from the principal figures, who are shown up clearly against the temple steps. Joseph is offering the ring, while the priest is guiding Mary's hand towards it, encouraging her to put it on. This is the theme of the picture, and the whole composition is arranged to draw our attention to it.

Raphael in Florence

Soon after painting this picture, Raphael went to Florence where many artists and sculptors were working; and here he came into contact with the great masters Michelangelo and Leonardo. He studied their works and learnt much from them.

While he was in Florence Raphael painted many of his 'Madonnas'. Among the loveliest of them is *The Madonna of the Goldfinches* with her soft, rounded outlines and serene expression.

The appeal of these paintings lies in their naturalness and tenderness. Although she is the mother of God, the Madonna in *La Belle Jardinière* is portrayed as an ordinary woman, barefoot and playing with her child. It is this simplicity, above all, that has given Raphael's paintings such a wide popularity.

A rather more formal painting is the Ansidei Madonna of 1506 or 1507. The clear-cut architectural features, and the careful balance of the figures on each side of the throne, show the progress Raphael had made during his stay in Florence.

The *Madonna of the Chair*, painted at a later date in Rome, shows Raphael's ability to make the best use of the shape of his canvas. As in *La Belle Jardinière*, the little St John is the least important person, yet the three figures are bound tightly together within the encircling frame.

The face of the Madonna from The Madonna of the Goldfinches, *in the Uffizi Gallery, Florence*

The Madonna known as La Belle Jardinière
(Louvre, Paris)

Work for the Pope

Raphael probably left Florence in 1508, and went to Rome, where Michelangelo was just starting to paint the ceiling of the Sistine Chapel. Raphael himself, although he was only 26, was entrusted by the Pope, Julius II, with the decoration of some new rooms in the Vatican. Each of these *stanze* (an Italian word

The Ansidei Madonna which can be seen in the National Gallery, London

The Madonna of the Chair (The Pitti Palace, Florence)

personality and character of whoever he was painting.

Raphael was for a time in charge of the building of the new St Peter's basilica, a job which he took over on Bramante's death in 1514. His ability to do many different things was typical of the Renaissance artists. Raphael, like Michelangelo and Leonardo da Vinci, was recognised as a great man, although earlier artists had mostly been treated as paid craftsmen. He died in 1520 at the early age of 37.

A detail from the Disputation concerning the Blessed Sacrament, *a fresco in the Vatican*

meaning 'rooms') had all four walls and the ceiling decorated with magnificent frescoes.

The first room is called the *Stanza della Segnatura* (the Papal Signature Room). In it are two large frescoes – the *Disputa* (or *Disputation concerning the Blessed Sacrament*) and the *School of Athens*. The other two walls are cut by windows and contain smaller frescoes – *Parnassus* and *Jurisprudence*.

Our illustration is taken from the fresco known as the *Disputa*, in which a number of figures are witnessing the apparition of the Holy Trinity – God the Father, God the Son, and the dove or Holy Ghost. You can see a hand in the top left corner of our reproduction: this belongs to St Augustine, and leads our attention down towards the kneeling secretary to whom he is dictating. In ways like this, the fresco is given movement and life within a balanced and harmonious whole.

On the opposite wall is the fresco entitled the *School of Athens*, which has the theme of philosophy. In this scene the two great philosophers Plato and Aristotle are surrounded by an audience within a vast architectural setting. It is interesting to see how Raphael was concerned not only with religious themes, which one would expect in the Vatican, but also with the culture and mythology of Ancient Greece. This is an important aspect of the Renaissance Humanism, with its emphasis on Man as well as God.

At the same time Raphael was working on other things, including his designs for tapestries to be hung in the Sistine Chapel. The cartoons (designs) for these tapestries are in the Victoria and Albert Museum, London.

While he was in Rome, Raphael also became a famous portrait painter and popes and princes were among his subjects. He did not use the rather stiff poses characteristic of earlier artists, but concentrated more on the

MOVEMENT OF THE EARTH (part three)

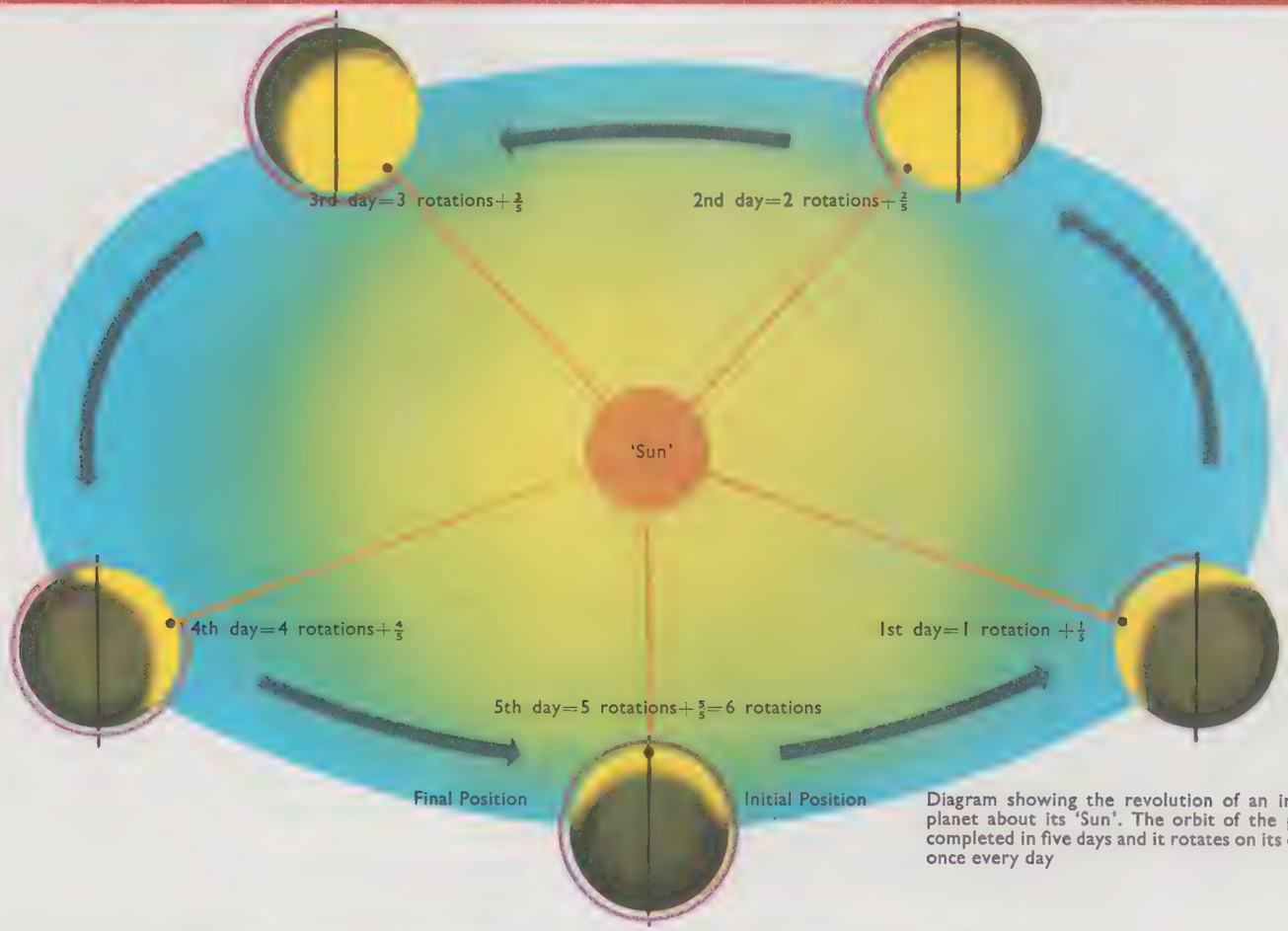


Diagram showing the revolution of an imaginary planet about its 'Sun'. The orbit of the planet is completed in five days and it rotates on its own axis once every day

IN the illustration we see an imaginary planet which is rotating about its own axis in addition to revolving in its orbit around another body which we will call its 'Sun'. The movements shown here are exactly those which occur in the movement of the Earth, but they are simpler because this planet only takes five days to complete one orbit round its 'Sun'.

Let us start measuring the movements when the point A is in the position shown in the lowest part of the orbit, which is labelled Initial Position. Using terms which we have learned in the two earlier articles, we may say that this is the time of transit of the 'Sun' across the meridian through A. At the end of one day, measured to the time when the 'Sun' crosses A for the second time, the planet will have completed one rotation about its own axis, plus one-fifth of its orbit around the 'Sun'. In other words, as we saw in the last article, the conditions of movement are similar to those which occur between successive transits of the Sun measured from some point on the surface of the Earth. At the end of two days the planet will have completed two and two-fifths rotations about its 'Sun', and so on. At the end of one complete orbit – that is, on the day of the fifth transit – the planet will have completed six rotations. This means that the movement in one complete orbit is equivalent to an extra rotation of the body about its own axis.

We know that it takes the Earth one year to complete its orbit round the Sun, or we can say that in 365 days it completes 366 rotations. However, just as there are several different ways in which we may measure one day, there are several ways also in which we may measure one year.

The duration of one orbit

If there were a fixed star in the ecliptic (the Sun's apparent path round the Celestial Sphere), the interval between the time when this star, the Sun, and the Earth lay on the same straight line in space would be a *Sidereal Year* made up of 365·256 mean solar days (that is, days of exactly 24 hours). However, there is not a fixed star in the ecliptic which can be used to give this measure. Instead, we may use the First Point of Aries (see page 1966) as the fixed starting-point from which this measurement can be made. This gives us the *Tropical Year* of 365·242 mean solar days. As we have seen, there is a small annual backward movement of the First Point of Aries along the ecliptic (Precession of the Equinoxes). This accounts for the smaller value for the tropical year. We should, however, note that the time required for one complete orbit of the Earth is about 365$\frac{1}{4}$ days, in which it completes nearly 366$\frac{1}{4}$ rotations.

We use a *Civil Year* of 365 mean solar days, with a leap year of 366 days every four years. This is known as the Julian calendar. This means that the average civil year is 365·25 mean solar days and is therefore 0·008 (or 11 minutes) longer than the tropical year. The slow accumulation of these minutes would mean that calendar dates would gradually become out of step with the seasons. In 11,000 years, if nothing had been done, January would have become a summer month. Pope Gregory XIII therefore revised the calendar in 1582 by suppressing three leap years in every 400 years. The average length of the civil year in the Gregorian calendar is 365·2425 mean solar days. The discrepancy from the tropical year is now so small that it will only amount to one day in 4,000 years.

The minor movements of the Earth

In addition to the rotation of the Earth about its own axis, and the revolution of the Earth in its orbit about the Sun, there are several much smaller movements. The most important of these is known as the Precession of the Equinoxes. This is a motion of the Earth's own axis of rotation as if in a cone. The axis of this cone is perpendicular to the plane of the Earth's orbit. The apparent effect of this is a movement of the celestial poles which trace small circles about two points which are the poles to the ecliptic (see diagram). The time taken for the celestial poles to make one revolution is about 25,800 years.

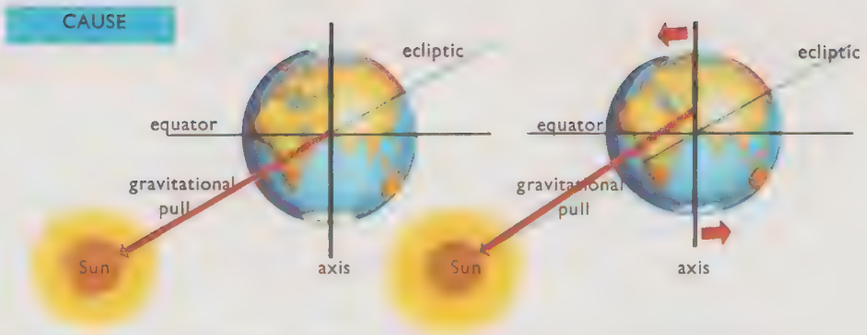
The main cause of this movement is the shape of the Earth. The Earth is not a perfect sphere but a *spheroid* or *ellipsoid* which, seen in section, has the shape of an ellipse. The major axis of this ellipse is the equatorial radius of the Earth; the minor axis is the axis of rotation through the geographical poles. The effect of the Sun's gravitational attraction upon this equatorial bulge is to try to turn the Earth's axis of rotation until this is truly perpendicular to the plane of its orbit. However, the Earth's own rotation prevents this from taking place. The physical explanation of this is similar to that for the movement of a spinning top or other form of *gyroscope* (see page 367). Gravity tends to make the axis of a top move downwards until the top lies on its side, but the spin of the top partly counteracts this force, converting it into a conical movement of the axis about the vertical.

There are two effects of precession which we can observe. The first is the progressive movement of the equinoxes (the First Point of Aries and the First Point of Libra) round the ecliptic; the second is the change in position of the celestial poles. Neither of these can be easily observed during a short time because the movement is so slow. The gradual precession of the equinoxes round the ecliptic has a rate of 50·26 seconds of arc per year. This small motion accounts for the slight difference between the length of the sidereal year and the tropical year. Continued for 2,150 years, however, it represents a movement of 30° and explains why the First Point of Aries is no longer in the constellation of that name.

The movement of the celestial poles has led to changes in the star which lies closest to this point. Thus, about 4,000 years ago the star nearest to the celestial pole was α *Draconis*. At present it is α *Ursae minoris*, which we call *Polaris*.

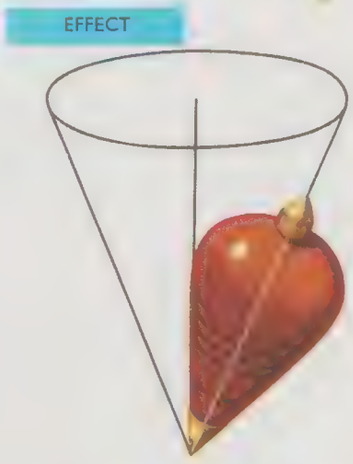
Further movement

A further movement is superimposed upon precession of the equinoxes. This complication results from the variation in the force which the Sun exerts on the Earth's equatorial bulge. When the Sun is crossing the Equator its gravitational pull no longer tends to turn the Earth's axis of rotation. The apparent movement of the celestial poles is not therefore uniform but comprises a series of small oscillations each of which takes 18·6 years to complete.

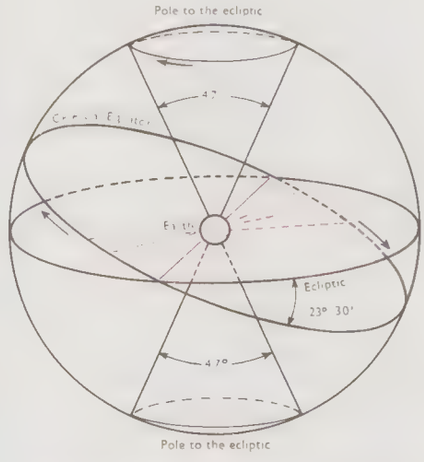


If the Earth were perfectly spherical, the gravitational pull of the Sun would pass through its centre and the axis would not be displaced

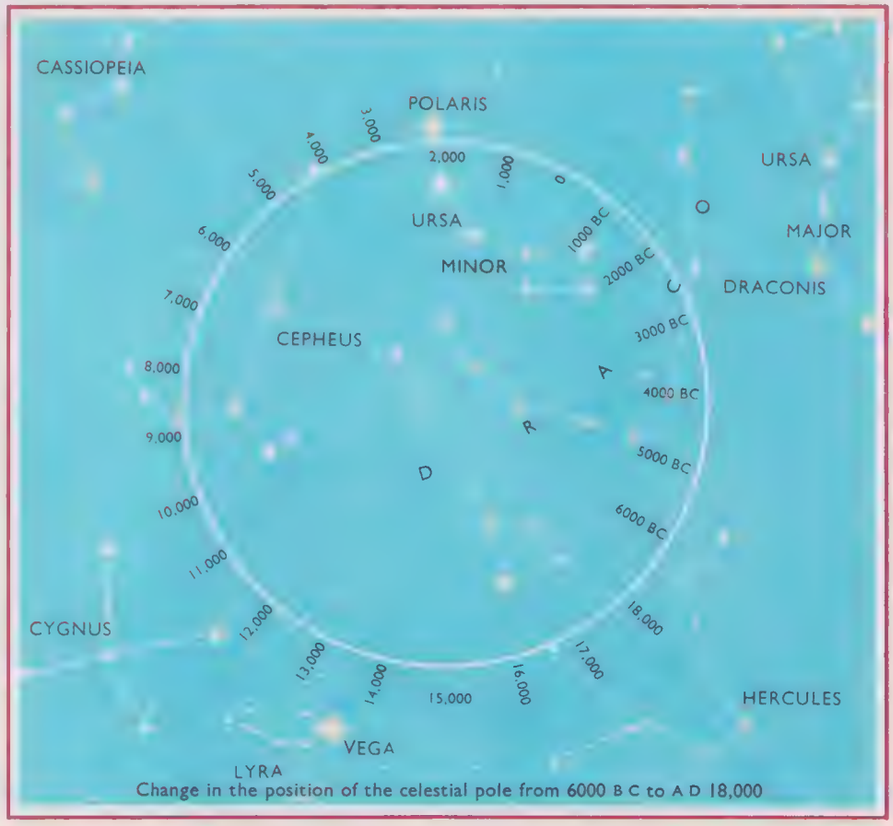
Because of the equatorial bulge the gravitational pull of the Sun operates within the opposite hemisphere and exerts a tilting force on the axis



The movement caused by precession can be compared to the movement of a top which describes a cone with its axis



Diagrammatic representation of the movement of precession which produces an annual advance of the spring equinox by about 50 seconds of arc



Change in the position of the celestial pole from 6000 B C to A D 18,000

SUMERIAN CIVILISATION

DURING his 12-year excavation of Ur, the ancient Sumerian city where Abraham was born, Sir Leonard Woolley made an interesting discovery. He and his colleagues were excavating the palace of a High Priestess of the Moon-god Nannar, the patron god of Ur. One room in the palace was full of clay tablets, used for teaching writing, and was clearly part of a boys' school attached to the temple. In the next room the archaeologists found some more clay tablets, part of a statue, a boundary stone, and other objects, lying on a brick pavement of the 6th century B C. These objects were between 700 and 1,600 years older than the pavement on which they lay. They could hardly have been brought together by accident. Then a small clay drum was found, inscribed with four columns of writing. This read: 'These are copies of bricks found in the ruins of Ur, the work of Bur-Sin, King of Ur, which the Governor of Ur found while searching for the ground-plan of the temple, and which I saw and wrote out for the marvel of beholders.' Bur-Sin was King of Ur in 2000 B C; the room was a museum of local antiquities, and the clay drum recorded the first scientific excavation of the city in 600 B C. This story gives us some idea of the antiquity of Sumerian civilisation.

The land between two rivers

Sumer was the ancient name given to the land between the two great rivers, the Tigris and the Euphrates, which flow through Iraq to the Persian Gulf. This land was raised above sea level by the silt carried down by the two rivers, and by other, smaller streams. When the marshes were drained the soil was extremely fertile.

The early Sumerians had no stone for tools, and they had to make their sickles out of dried clay. But there was wood for building ships to sail upstream or across the Persian Gulf, taking traders and their wares to other countries.

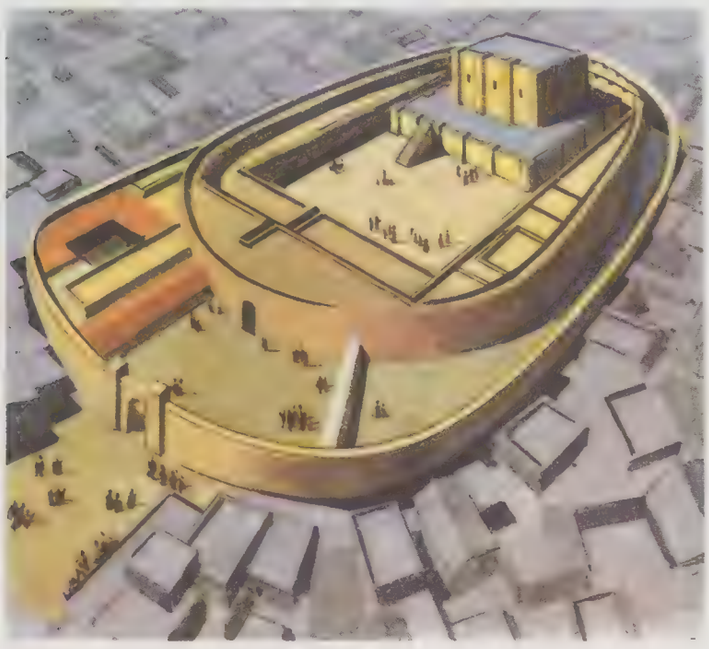
By 4000 B C, the early villages of reed huts built round local shrines had grown into towns with populations of several thousand like Eridu, Uruk, Lagash, and Ur. All kinds of craftsmen lived in these early Sumerian cities, as well as merchants and traders, but the most important people were the priests. The Sumerians were religious people, and paid regular tribute to their gods. The priests looked after the land round the shrines, and directed the work carried on in and around the temples. The temples were rebuilt many times, because the Sumerians believed that to repair a temple would bring favour from the gods. Each temple, after serving its time, was filled in with brickwork to become the foundation for the next; so the temple mound, or *Ziggarat*, grew higher and higher, until it dominated the whole town.

Written records

The Sumerians used clay tablets for writing, and once these were baked, they lasted thousands of years. The earliest tablets have simple pictures and numbers scratched on them. They are accounts kept by the priests, lists of cattle, flocks of sheep, wheat, barley, and dairy products, and records of receipts and expenditure. As time went on, these pictures became simplified, until eventually they were only symbols marked in the clay by a reed stilus, or pen. These marks were wedge-shaped or *cuneiform* (see page 1158), the name given to Sumerian writing.

From about 3000 B C on, the names of kings, or city-governors, begin to appear in the records. They were closely connected with the patron gods of cities, and called themselves 'tenant-farmers' of the gods. They were also war leaders, and the victorious king assailing his enemies is a favourite theme in Sumerian art.

In a Sumerian city, near the city wall, a chariot has just passed through



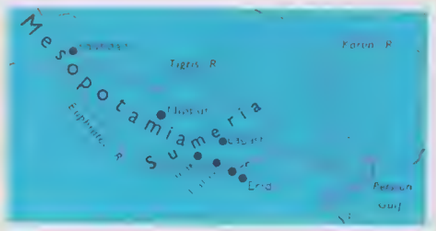
A large temple built by the Sumerians; note the characteristic oval ground-plan. The city was grouped around the building

THE ROYAL CEMETERY

The discovery in 1926 of a Royal Cemetery, just outside the temple enclosure at Ur, is one of the most thrilling events in the whole history of excavation. The first undisturbed tomb to be found was that of an unknown lady wearing a gold head-dress and holding a gold tumbler to her lips. A magnificent gold dagger and seal belonging to a prince were found in the shaft leading to the tomb, as though they had been thrown down in a farewell gesture. The next tombs discovered were those of a man and woman, identified by inscribed seals as Abargi and Shubad. They were probably a king and queen of Ur, since they were surrounded by attendants: soldiers wearing copper helmets and carrying spears and daggers, and magnificently dressed court ladies. Each of these attendants had brought with them a little cup of poison which they had taken, sure of continuing to serve their king and queen in another life. There were also animals in the tombs, drawing wagons and chariots, which had been sacrificed so that they too might enter the after-world with their master and mistress. Some of the treasures found in the Royal Cemetery at Ur are on view in the Babylonian Room of the British Museum in London.

the gates carrying soldiers; the wheels are made of solid wood with leather tyres

Statue of a Sumerian god called Abu



The larger Sumerian cities

The Sumerians taught themselves to calculate, beginning with dots stamped on clay. They invented a special symbol for the number 10. They also invented a sun-dial and a water clock for measuring hours, and standards for weights and measures. Wages and rents were paid in barley, but silver and copper were used in exchanging goods.

Sumerian buildings

The daily life of the Sumerians seems to have been very like that of Iraqi peasants today. Their towns, too, must have been similar; the streets were winding, narrow, unpaved lanes; the houses were like those of any small modern Iraqi town except that the Sumerian doorways were usually arched, since there was a shortage of wood for lintels, and the rooms were narrower. Each house was built round a central courtyard on to which all the ground-floor rooms opened. A staircase led to the family's rooms upstairs. The later Sumerians buried their dead in vaults under the paved yard at the back of the house, where there was also a family chapel and altar.

A towering Ziggarat overlooked the Sumerian town, and was the last stronghold of its defence. The city of Ur was fortified by outer walls, inner walls enclosing the temple precincts, and a 36-foot-thick wall enclosing the Ziggarat. The small shrine at the summit was used chiefly at the great New Year festival, connected with the watering of the land and the fertility of crops. The dazzling procession of priests and leading citizens, the king (taking the part of their god) and his court, would wind its way up the triple staircase to the top of the temple tower. From the summit they would see the smoke of sacrifices rising from distant shrines; then they would offer the ritual sacrifice of living creatures which the gods required.

CARBON DIOXIDE

BEFORE the second half of the 18th century, chemists paid little attention to gases. Although it had been known for many hundreds of years that 'vapours' or 'airs', as they were called, were given off during many chemical reactions, no one had bothered to investigate them seriously. In 1755 Joseph Black, who later became professor of chemistry at Edinburgh University, published the results of his investigations with chalk, 'magnesia alba' (magnesium carbonate), and lime. In this publication he first described fully the 'fixed air' which was given off when chalk was heated. Black's 'fixed air' would recombine with lime and convert it back again to chalk, and was in fact carbon dioxide. The changes (see page 1173) which were first explained by Black can be written down in the following chemical equations:

(1) $CaCO_3 \xrightarrow{\text{heat}} CaO + CO_2$

Calcium carbonate (Chalk) — Lime (Calcium oxide) — Carbon dioxide

(2) $CaO + CO_2 \longrightarrow CaCO_3$

Lime — Carbon dioxide — Calcium carbonate

Carbon dioxide is a colourless gas with a slight, characteristic smell, and a mild acid taste. It is about half as heavy again as air, and is quite soluble in water. Nothing can burn in it, and it will not support life. It is produced when limestone is converted to lime by heat, and from the action of acids on carbonates. When sugar is fermented by yeast, alcohol and carbon dioxide are produced.

The Grotta del Cane

OCCURRENCE AND MANUFACTURE

Carbon dioxide forms about 0·03 per cent of the earth's atmosphere and is present in a larger proportion in the air breathed out from the lungs of animals. Enormous quantities are locked up as carbonates in combination with sodium, calcium, magnesium, and other metals.

In a few places in the world almost pure carbon dioxide comes out from fissures in the ground as a result of volcanic action. The famous *Grotta del Cane*, near Naples, is a cave containing an invisible 'pool' of carbon dioxide which cannot escape because it is heavier than air. Since carbon dioxide is unable to support life, any man or animal venturing into this cave is rapidly suffocated. In our picture the dog is totally immersed in the gas, and would rapidly die if not removed. The man's head is above the level of the gas, and if he goes no farther into the cave he will be unaffected.

Carbon dioxide is obtained commercially from the gases coming from lime kilns, and from the gas given off during fermentation. In order to transport it without difficulty, it is compressed into steel cylinders or frozen to form 'dry ice'.

THE PROPERTIES OF CARBON DIOXIDE

Chemical formula: CO_2 **Molecular weight:** 44
Density (air = 1): 1·53 **Freezing point:** −78·5°C

1·79 volumes of the gas dissolve in 1 volume of water at 0°C and one atmosphere pressure.

Solid carbon dioxide does not melt when warmed at normal atmospheric pressure but *sublimes* – that is, it changes directly from solid to gas. The gas can be liquefied under high pressure.

AN INTERESTING EXPERIMENT

Because carbon dioxide is so much heavier than air it can be poured from one container to another like a liquid. Figure ① shows carbon dioxide being poured into a wide glass jar in which four candles are burning, arranged one above the other. As the level of the gas rises in this jar the candles go out one after another. The carbon dioxide has extinguished them by preventing the air needed for combustion from reaching them.

USES OF CARBON DIOXIDE

Carbon dioxide is used in fire extinguishers, mainly for putting out small oil and petrol fires, and fires in equipment which would be damaged by water. The extinguisher shown in figure ② is filled with carbon dioxide under high pressure, and when the valve is opened a jet of gas sprays on to the flames and smothers them.

Much carbon dioxide is used in the manufacture of 'fizzy' mineral waters and soda water ③. The gas is dissolved in the mineral water under pressure and is released as innumerable tiny bubbles when the bottle is opened.

Solid carbon dioxide, 'dry ice', is used as a refrigerant for icecream and frozen foods, and in laboratories.

The Zimbabwe bird – a clue to the past?

The inner citadel of Zimbabwe.

THE MYSTERY OF ZIMBABWE

A conical tower at Zimbabwe which has an early Egyptian look.

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DEEP in the African bush, 500 miles from the Mozambique coast and midway between the Limpopo and the Zambezi rivers, stands the temple of Zimbabwe. It is Southern Rhodesia's greatest tourist attraction, and is one of the most mysterious buildings in the world. Who built it? Who first lived in it? No one knows for certain.

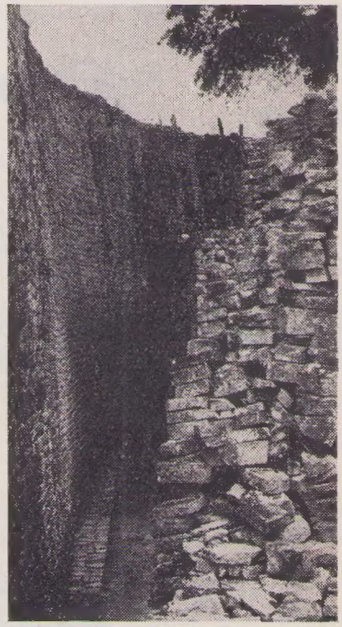
Zimbabwe is a massive circular stone fortress, constructed completely from local material, without the use of cement. There is nothing exactly like it in construction in Africa, or, indeed, anywhere else in the world.

Zimbabwe, in the local vernacular, means 'place of the Zimbas'. The Zimbas left Africa for Mozambique ('land of the Zimbas') a long time before the white man came. There are traces of their habitation around Zimbabwe, but did they have anything to do with the building of the *present* temple? If radioactive fossil tests on the present walls are to be believed, they probably did not. These tests suggest that the walls were built around the 11th century AD. They may not have been by any means the first walls. Indeed there are charcoal deposits in the temple dating from as early as AD 400. But even by the latter date the Zimbas had long since left Zimbabwe, so, on the evidence of the fossil tests, they could not have built the present temple.

Who, then, could have built it? A strange stone bird, found in Zimbabwe, gives a clue. It is very similar to those which the Ancient Egyptians used to paint and carve to adorn their temples and tombs. The presence of this means it is just possible that the founders of Zimbabwe might have come from Egypt after the Zimbas had left the area; certainly the buildings of Zimbabwe, if they show any influence, show that of Egypt. But this is no real proof as to who Zimbabwe's founders were.

We do, however, know something definite of Zimbabwe in mediaeval times. Since the 15th century the Arabs employed it for business – in fact, for the slave trade. They used the temple as a meeting place, and later kept the slaves there before transporting them to slavery.

Yet Zimbabwe's history before the coming of the Arabs remains a mystery, and we may never know why its founders vanished, leaving no trace but the strange temple rising majestically out of the bush.



The walls of Zimbabwe have no cement and are excellently preserved.

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FLYING FISH AND OTHER ANIMALS

It is strange but true that one airline carries more goldfish in a year than it does passengers. Here are some amusing facts about other animals that have to be transported by plane. Tropical fish are packed in water-filled plastic bags with a supply of air enriched with extra oxygen, and are kept warm with a special outer wrapping of insulated material. Lobsters are packed close together so that they cannot move about, and their claws are tied to prevent them pinching each other. Pilots with lobsters as freight should not fly too high, and must avoid a bumpy passage, otherwise the lobsters suffer from cramp.

BURIED IN BOOTS

Boot hill was the cowboys' name for a cemetery. This name was given to cemeteries in the hectic days of gun-fights and sudden death in the old Wild West. Those who died were often outlaws or bandits, with no one to pay for a proper funeral, so that the bodies were hurriedly buried, fully clothed and with their boots still on. Perhaps the most famous of all *boot hills* is the cemetery outside Tombstone, Arizona, where more than 300 gun-fight victims are buried. Wooden headpieces still mark some of the graves, briefly telling a story such as: 'Here lies Lester Moore; four slugs from a forty-four; no less – no Moore.'

SOLID INK

Many years ago ink was solid, made from lampblack and a kind of glue. It came from China and India. Nowadays, this ink, called Indian ink, is used by artists in liquid, not solid, form. The Chinese also made it in the form of a pencil, which one had to moisten before use.

ALL-PURPOSE PEANUT

You are now looking at peanuts. You are probably wearing peanuts as well, and your next meal is sure to contain them. For peanuts are used in the production of the printers' ink on this page, and they go to the making of clothes, face-powder, soap, salad-cream, margarine, flour, cheese, axle-grease and linoleum, to mention just a few. Medicines contain them, and they help the treatment of paralysis and other complaints. Today, 27 million acres are given over to growing peanuts in India and China, and another million in America. The shells are blended with cotton and wool to make fabrics, while there is also a large trade in salted and roasted peanuts – just for eating.

Announcement for readers of YELLOW Knowledge

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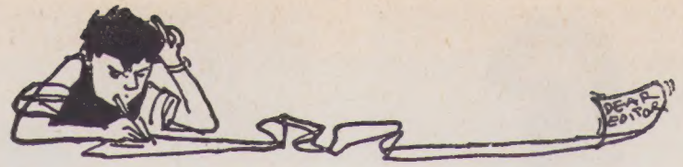
This issue is the first of Volume 7. In the centre of Knowledge *this week is the index for Volume 6. This goes on the last string of your Volume 6 standard binder, or the last rod of your Volumes 5 and 6 Easibinder.*



A Hero's House

DEAR EDITOR—On Easter Monday I went to Blenheim Palace, the home of the Duke of Marlborough, and birthplace of Sir Winston Churchill.

This magnificent palace was built by Sir John Vanbrugh between the years 1705 and 1722. Queen Anne gave John, First Duke of Marlborough, £240,000 to help in the construction, because he fought for England abroad.

In the palace there are many paintings and tapestries. There is a painting of George, fourth Duke of Marlborough, and his family by Sir Joshua Reynolds, and one of the ninth Duke by Sargent. There is a tapestry showing the Battle of Blenheim in which Marshal Tallard, commander of the French forces, surrenders to Marlborough.

The library was largely built up by the late Duke and contains thousands of books, as well as a statue of Queen Anne at one end.

Charles Bale,
Mardene,
281 *Marlpool Lane,*
Kidderminster.

There is an article about the reign of Queen Anne in Knowledge No. 14 *that you might find interesting.—Editor.*

Place-names

DEAR EDITOR—The longest place-name in Great Britain is the concocted name Llanfairpwylgwyngyllgogerychyndrobwllllantysiliogogogoch. This means: St Mary's church in a hollow by the white hazel, close to the rapid whirlpool, by the cave of St Tysilio. The true name consists of the first 20 letters. The longest Welsh name listed by the Ordnance Survey is Lanvihangelystern-llewern.

The longest place-names of a single word in England are Stokeinteignhead, and Woolhardisworthy, both in Devonshire.

The longest multiple-word place-name is Preston upon the Weald Moors, in Shropshire.

In Ireland, the longest place-name is Newtownmountkennedy, in County Wicklow.

John Anstey (*age* 12),
188 *Weir Road,*
*Balham, S.W.*12.

Believe it or Not

DEAR EDITOR—Here is a problem for those keen on puzzles.

A man went to the blacksmith to have his horse shod. The blacksmith stated that 32 nails were needed; the first nail would cost ¼*d*; the second 1*d*; the third 2*d*; the fourth 4*d*; and so on, doubling the cost each time. What was the total cost?

Believe it or not, it was £8,947,848 10*s*. 7½*d*.

I. Hassan,
51 *Cornwall's Parade,*
Gibraltar.

Mahomet's Life

DEAR EDITOR—I was very pleased to see an article about Mahomet, especially as I am a Muslim girl. May I tell you a little more about the Prophet's life?

Mahomet was the son of Abdullah of the tribe of Qureysh. His father died before he was born and he was first protected by his grandfather, Abdul Mutallib. Later his uncle, Abu Talib, looked after him. As a young boy, Mahomet travelled with his uncle in the merchants' caravan to Syria. Some years later he made the same journey in the service of a wealthy young widow named Khadijah. So well and faithfully did he transact her business, that Khadijah soon married her young agent. Throughout the 26 years of their life together, Mahomet remained devoted to Khadijah, and after her death he always mentioned her with the greatest love and reverence. This marriage gave him rank among the notables of Mecca, while his conduct earned for him the surname 'Al-Amin' – 'The Trustworthy'.

Fay Atcha,
64 *Hawgone Road,*
Maymyo, Burma.

Horse Sense

DEAR EDITOR—Two men were each given a horse but had difficulty in telling the two apart. One man cut the tail off his horse, but it soon grew again. The other man cut the mane off his horse, but that also grew again. Soon, one man suggested that they measure the horses, as one might be taller than the other. Sure enough, the black one was four inches taller than the white one.

Peter Timms (*age* 13),
4 *Laxdale Road,*
Burwood,
Victoria, Australia.

Can you answer these?

GIVE THE MIDDLE TERM IN THE FOLLOWING SERIES:

1. 11, 14, —, 20, 23.
2. i, iv, —, x, xiii.
3. $\frac{A}{B}, \frac{B}{C}, —, \frac{D}{E}, \frac{E}{F}$.

PUT ONE LETTER BEFORE AND ONE LETTER AFTER THE EXPRESSION ON THE RIGHT SO THAT THE WORD THAT RESULTS RHYMES WITH THE WORD ON THE LEFT:

4. RISE; –YE–.
5. TOWER; –U–.
6. LEAN; –IE–.

WHICH WORD WITHIN THE BRACKETS IS THE OPPOSITE OF THE WORD IN CAPITALS?

7. LIGHT (fair, electric, heavy, ton).
8. SUPERIOR (employer, cellar, medium, inferior).
9. OBVIOUS (obscure, clear, dark, cover).

ANSWERS

1. 17.
2. vii.
3. $\frac{C}{D}$
4. EYES (or AYES; BYES; DYES).
5. OUR.
6. MIEN.
7. Heavy.
8. Inferior.
9. Obscure.

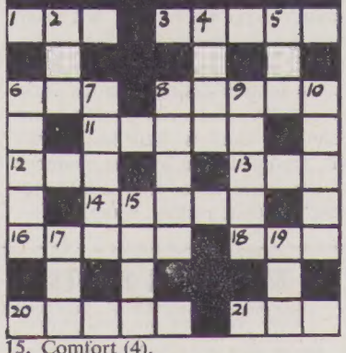
BRAIN ? BOX

1. Sentence from history book: 'Penny postage was first introduced into Great Britain by Rowland Hill in 1840.'
   Right or wrong?
2. The other day I found I could run from the bottom of the river bridge to the halfway mark while the church clock struck six. The next day I ran all the way over the bridge while the clock struck twelve. Did I run faster, slower, or at the same speed on the second day?
3. Can you say whether these statements, based on latitude and longitude, are right or wrong? (a) Edinburgh is east of Bristol; (b) Middlesbrough is west of Hull; (c) Beachy Head is north of Bodmin; (d) York is south of Blackpool; (e) Penzance is west of Belfast; (f) Berwick-on-Tweed is west of Southampton.

ANSWERS

1. Wrong. Penny post was already in operation in London and the surrounding area. In 1840 the system was extended to the whole country.
2. Slower. (It takes the clock more than twice the time to strike 12 than six, as there are there are five when it strikes six.)
3. (a) Wrong; (b) right; (c) right; (d) wrong; (e) wrong; (f) right.

HIGH-SPEED CROSSWORD



Clues Across

1. One who tries to see what he should not (3).
3. Lead or line (electric or telegraph) (5).
6. Affirmative reply (3).
8. Uncultivated open land (5).
11. Appeal (for something or someone) (5).
12. Respect (3).
13. —— and sceptre (3).
14. Always is the opposite (5).
16. Tomorrow's yesterday (5).
18. Devour (3).
20. Hail (5).
21. 18 across is now past (3).

Clues Down

2. Might be apple and then might be in bed! (3).
4. Base by half height gives a triangle's (4).
5. 'Without —— or hindrance' (3).
6. It makes the dough rise (5).
7. Put money to use (5).
8. Not light (5).
9. Worship (5).
10. A way you get into and find hard to shake off (5).
15. Comfort (4).
17. Possessive adjective (first person plural) (3).
19. Perform (on the stage, for example) (3).

Solution next week.

SOLUTION TO LAST WEEK'S CROSSWORD

ACROSS: 1, Spain; 4, Sob; 6, Retrieves; 7, Neck; 8, Eric; 10, Bleaching; 12, Bus; 13, Owned.

DOWN: 1, Sir; 2, Attackers; 3, Nail; 4, Sovereign; 5, Basic; 7, Nabob; 9, Echo; 11, God.

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CLASSIFICATION OF THE SCIENCES

A special branch of science has developed for each different type of subject matter. In the last 100 years a great many new branches have grown out of what used to be small parts of other sciences. But the various branches are not neatly cut off from one another. In some cases the borderlines disappear: atomic physics belongs to chemistry as much as to physics. Moreover, the methods and results of one field are often applied in another: physics and chemistry are both very important in physiology.

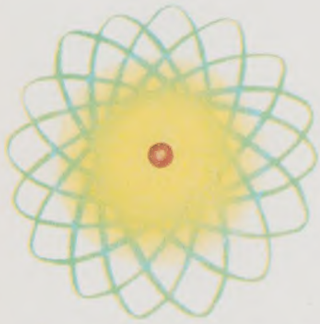
To set up a clear and comprehensive classification of the sciences is not a task for the scientist as such, but rather a special pursuit that belongs to the field of philosophy. From ancient times philosophers have sought to classify the sciences. In detail this is often difficult and may be provisional: as various fields develop, their bearing on one another and their place in science as a whole may change somewhat. But there are some broad distinctions that can usefully be made. Thus we put on one side the formal disciplines of *logic*, the science of correct reasoning, and *mathematics*, the science of numbers. The so-called 'real' sciences are divided into *natural* sciences, dealing with nature round us, and *social* sciences, dealing with men and their industries.

THE NATURAL SCIENCES

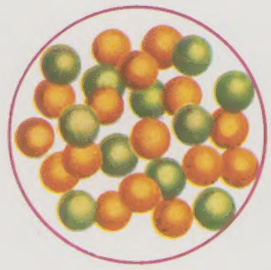
These are usually divided into physical and biological sciences. In the physical sciences we deal with the general material 'nature' of things (from the Greek word *physis*, which roughly translated means the way things are, materially). In the biological sciences we study living things (from the Greek words *bios*, life, and *logos*, study).

Physical sciences

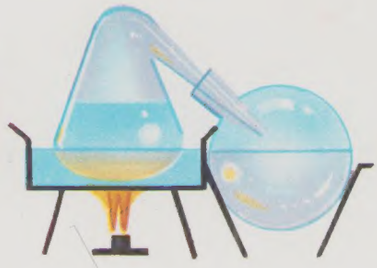
Foremost among these is *physics*, which has many branches. In physics we are concerned with the general behaviour of the material world. The main branches of physics are: mechanics, the study of the motion of bodies; heat; sound; light; electricity; atomic and nuclear physics. These various branches are not always neatly separated but are used in combination with each other. Thus heat and sound may be explained as mechanical phenomena; light, on the other hand, is now recognised as a form of electromagnetic radiation.



Example of the structure of an atom



Structure (enlarged) of a nucleus



Chemical apparatus

Atomic physics deals with the properties and the structure (the nucleus and its electrons) of the atom.

Nuclear physics deals with the properties and the structure (protons and neutrons) of the atomic nucleus.

Chemistry studies internal changes of matter. Parts of it belong also to physics.

The moon with its characteristic craters

Astrophysics deals with the physical structure of the heavenly bodies.

Astronomy deals with the position and motion of heavenly bodies.

Stratified rock.

Geology deals with the make-up and structure of the Earth's crust.

Biological sciences

The chief branches of *biology* are:

Zoology, which deals with animals.

Botany, which deals with plants.

Physiology, the study of how organs function and are linked with each other.

Biochemistry, the study of

Tiger and tiger's skull, which are studied in *zoology*.

Sectional view of the organs of a flower, which are studied in *botany*.

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Science (part two) *Cover*
Vegetation of the savannah and steppe *1985*
Elizabeth and her sea-captains *1988*
The Lesser Antilles and the Bahamas *1990*

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Pi (part two) *1992*
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Movement of the Earth (part three) *1996*
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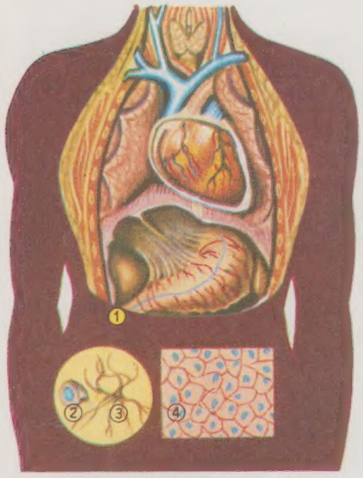
Carbon dioxide *2000*

contents



① Internal organs. Examples of ② an epithelial cell, ③ a nerve cell, ④ an epithelial tissue

how organs, and the 'fuel' they take in, undergo chemical changes.

Ecology, which deals with the geographical distribution of animals and plants.

In zoology and in botany we are partly concerned with the actual form or shape of animals and plants. This part of the study is called *morphology*, and if the observations are on dissected specimens, it is called *anatomy*. The study of tissue is called *histology*, that of cells *cytology*.

The study of the shape of fossil remains is called *palaeontology* (from the Greek *palaios*, old, and *ontology*, the study of what is), and through it we try to reconstruct what kinds of plants and animals existed long ago.

Skeleton of a Megatherium

Two examples of fossilised Echinoderms

The main fields of applied biology are *agriculture* and *medicine*.

But this brief classification of the natural sciences does not show how much the various fields overlap one another. A geologist must know a great deal of physics and chemistry, and so must biologists in almost any branch of their subject. Some knowledge of mathematics is essential in any scientific work. Any classification of the various sciences is bound to be a rough guide only, and we must not try to divide them up into rigidly separate compartments.

Map showing (in green) the part of Africa where elephants live

THE SOCIAL SCIENCES

In the social sciences we deal with men, their institutions and their ways of life, and traditions. The oldest social science is probably *history*, which deals with the actual deeds of men in time. From this historians may try to reach some conclusions as to the best way of governing a state, both internally and in its relations with other states. This is the field of *political science*. History also provides the basis for *social theory* or sociology, the general theory of human relations in society. In its practical applications sociology has lately become rather important: town-planning, industrial development, educational policy – all these must be pursued with proper regard to the findings of sociology.

Psychology, the science of how the human mind works, is another social science. So is *economics*, the study of how goods and services are produced and distributed.

Anthropology deals with the cultural, social, and spiritual habits and traditions of the various races of men.

Mask of an evil spirit and characteristic drum of the natives of Liberia

The interesting thing about the social sciences is that, historically, their origins lie much further back than those of the natural sciences. When men first began to think about themselves and the world, it was their own social life which lay nearest to hand for reflection. To begin with, they understood everything that happened round them in terms of their own experience as members of human groups. Hence in primitive times men thought that all objects in nature had souls or spirits, and it is in this way they sought to explain natural events. It is for this reason that the theoretical language of science is full of terms that belong to the organisation of human groups. One need only think of the term 'law' to recognise this.

Some people deny that social sciences are really 'scientific', because their results are not accurate enough. However, what makes a subject scientific is not accuracy but the general method of approach.

Gallic inscription cut on stone. On the right: a historical document